R E P O R T R E S U M E S

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THE EFFECT OF SELECTED SPATIAL DESIGN FACTORS IN EDUCATIONAL DISPLAYS ON LEARNING AND RETENTION.

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CRITERIA WERE DEVELOPED FOR THE DESIGN OF LABELS IN VERBAL-PICTORIAL EDUCATIONAL DISPLAYS. THE INFLUENCE OF SPATIAL DISTRIBUTION OF LABELS ON EASE OF LEARNING AND DEGREE OF RETENTION WAS INVESTIGATED. THIRTY ANATOMICAL PARTS OF THE HUMAN DIGESTIVE TRACT WERE LABELED ON 10 CHARTS SHOWING THE SAME DIAGRAM OF THE HUMAN BODY, BUT WITH DIFFERENT PATTERNS OR SPATIAL DISTRIBUTION OF LABELS. THE SAME LECTURE WITH VARIED LABEL PATTERNS WAS PRESENTED TO 309 10TH-GRADE BIOLOGY STUDENTS IN 14 CLASSES. STUDENTS COMPLETED A 5-MINUTE PRETEST, A 5-MINUTE POST-TEST, AND 2 WEEKS LATER, A 5-MINUTE RETENTION TEST. ALL TESTS WERE FACSIMILES, MINUS THE IDENTIFYING LABELS, OF THE PROJECTED TWO-DIMENSIONAL VISUAL AID PATTERN USED IN THE ORIGINAL INSTRUCTION OF THAT PARTICULAR CLASS GROUPING. THE ABILITY LEVEL OF EVERY STUDENT WAS OBTAINED FROM SCHOOL RECORDS. SEVERAL VARIATIONS OF LABEL PATTERNS APPEARED TO HAVE EQUIVALENT INFLUENCE ON ACQUISITION AND RETENTION, THEREBY PROVIDING A BASIS FOR ALTERNATE LAYOUTS BY DESIGNERS OF SUCH EDUCATIONAL DISPLAYS. THE CURRENT RESEARCH FAILED TO DEMONSTRATE DIFFERENCES BETWEEN GROUPS VIEWING VARIOUS LABEL PATTERNS. (JK)

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Educational Research Unit

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Preface

The present report was prepared under Research Grant No. 719132 (The Development and Validation of Selected Design Criteria for Graphic Training Aids) sponsored by the Department of Health, Education and Welfare under provisions of Title VII of the National Defense Education Act of 1958 (P.L. 85.864). The specific purpose of the current project was to undertake a limited program of research which would permit the derivation and validation of principles pertinent to the design of visual aids.

The authors are indebted to the U.S. Department of Health, Education and Welfare for the fiscal support of the research. Furthermore, the authors are grateful to the following for the cooperation extended them throughout the report study: Mr. Ara Karakashian, Principal; Dr. Helen Zimmerman, head of Science Department; Mr. David Garland, science instructor; Mr. Jerome Pierianowicz, science instructor; Mr. Walter Paskowsky, Director of Guidance of the Reading High School, Reading, Mass.; Mr. Manfred L. Warren, Assistant Director of Instructor; Mr. Laurie L. Harris, Assistant Principal; Mr. Frederick Thurlow, Assistant Principal; Mr. Julius C. Batalis, science instructor; Mr. John A. Rennie, science instructor; Mr. Alfred A. Rocci, Jr., science instructor; and Mr. David L. Wilson, science instructor of the Lexington High School, Lexington, Mass. To the students in the Lexington and Reading schools who served as subjects and to John F. Howell, Nancy Soscia and Edward B. Spalding, graduate assistants on the project, a special note of appreciation.

The Effect of Selected Spatial Design Factors in Educational Displays on Learning and Retention

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Introduction

An earlier review of the literature (Saul, et al, 1954)[1], pertinent to the design of graphic training aids revealed a gap in the available research pertaining to criteria for the design of labels in verbal-pictorial educational displays (e.g., biological cross-sections containing pictorial representations of cells with accompanying labels of cellular parts). What specific research findings and generalizations were available, usually related to such notions as label elements should be large enough to be seen, label elements should not be excessively crowded, label elements should be esthetically pleasing, etc. In no instance were data available regarding the influence of the spatial distribution of labels on the ease of learning and degree of retention of label elements. The current study has been designed to explore the influence of spatial distribution of labels on ease of learning and degree of retention.

The problem may be conceptualized as an instance of paired-associate learning in which the stimulus elements are pictorial in character and the response elements are verbal. Furthermore, the distribution of verbal labels

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1. Saul, Ezra V., et al. Technical Report SpecDevCen 494-08-1. A Review of the Literature Pertinent to the Design and Use of Effective Graphic Training Aids. SDC Project 20-D-3; Contract Nonr-494(08) 24 February 1956, U.S. Naval Training Device Center, Port Washington, L.I., New York

throughout the total display may be thought of as a pattern or configuration of sub-elements within the total design. In the case of this latter consideration, the principles of symmetry and "good figure" as described by the Gestalt psychologists may be considered to apply, through such inferred processes as perceptual organization of the visual field.

It was specifically hypothesized in the current study that there would be different degrees of learning and retention of various label patterns: e.g., labels which were uniformly aligned at the side of the diagram would be less well-learned than labels which were placed in various unaligned arrangements; and labels which were grouped in keeping with some principle or organizing schema would be more readily learned and remembered than labels that were not so organized, etc.

Method and Procedure

The subjects were 309 tenth-grade biology students from a public high school located in a predominantly middle-class, white-collar community.

The "experimenter-teacher" explained to normal class groups that they were participating in a study concerned with the learning of biological information. The students were then given a five-minute pretest. Following the pretest, a two-dimensional visual aid was projected on a screen using an overhead transparency projector. The experimenter then lectured for thirty minutes pointing out anatomical parts and discussed physiological processes pertaining to the topical content of the chart. At the conclusion of the lecture, a five-minute post test was given. Any questions that the students had during presentation were answered at this time. Two weeks later an unannounced five-minute retention test was administered. All tests were

facsimiles, minus the identifying labels, of the projected two-dimensional visual aid pattern used in the original instruction of that particular class grouping. Fourteen classes[2] were taught thirty anatomical parts of the human digestive tract, e.g., cardiac valve, ileocecal valve, hepatic duct, etc. A single lecturer was used for all classes and a single grader was used for the scoring of all pre, post and delayed retention tests. Although label patterns and the ability of the groups varied, lecture presentation accompanying all of the presentations was held constant.

The ability level of every student participating in the study was obtained from school records and were either Otis or California tests of mental maturity reported in IQ units.

The label patterns (i.e., spatial distribution) used included:

A) all labels on the right side with functional grouping

B) a legend pattern

C) functional groupings of labels with one group in a unique color

D) a circular pattern

E) all labels on the left side

F) all labels on the right side

G) half of the labels on each side

H) a functional grouping of labels with no color modification

I) all labels on left side with three out of line

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2. Initial interviews with school authorities suggested that a sufficient number of homogeneously "low" and "high" intelligence (IQ) classes would be available to permit testing each of the ten (10) label patterns with one (1) "high" and one (1) "low" group. Unfortunately, actual circumstances did not permit the implementation of such an original design.

C) and a cross-over pattern

The patterns of all labels aligned on right (F) or left (E) side may be considered to be mirror images. The legend (B) pattern involved a number being attached to an arrow going to a pictorial element which could be deciphered by referring to a list of numbers and labels to one side of the pictorial display. The functional (A, G, H) patterns with and without color simply reduced the spatial distance of labels pertaining to gross units of the body with greater degrees of physical space between these units of labels. The cross-over (J) pattern had a limited number of lines or arrows connecting pictorial and verbal labels cross each other and was considered to be a maximally inappropriate pattern for the learning and retention of labels. The circular (D) pattern may be considered a simplification of the legend (B) pattern with no need for a shift of visual fixation for "decoding" the numerical labels. The "out of line" pattern (I) may be thought of in terms of introducing spatial heterogeneity in pattern (E) all labels on left side.

Results

The descriptive statistics for the fourteen groups learning the labels of the human digestive system are presented in Table I. This table summarizes the number of cases in each group, the mean and standard deviation in IQ for each group, and the mean and standard deviation of pretest, post-test, and depayed retention scores (i.e. number of items correct). In addition, this table contains the means and standard deviations of learning scores and forgetting scores (i.e. learning score = the difference between Pre and Post test scores and the forgetting scores = the difference between Post test and

Table

Treatment Groups and Descriptive Statistics

Treatment	N[1]	I.Q. M	I.Q. S.D.	Pre Test M	Pre Test S.D.	Post Test M	Post Test S.D.	Ret. Test M	Ret. Test S.D.	Amt. Learned M	Amt. Learned S.D.	Amt. Forgotten M	Amt. Forgotten S.D.
A	23	114.2,	6.53	3.3,	2.88	18.7,	5.73	12.6,	6.09	15.6,	4.87	6.3,	5.12
B	23	122.7,	7.01	4.3,	2.27	21.0,	5.71	15.6,	6.63	16.7,	5.56	5.5,	5.19
B*	25	110.0,	7.33	5.5,	4.07	17.7,	6.0	13.3,	6.38	12.2,	3.83	4.7,	3.47
C	23	114.4,	7.22	3.9,	3.35	14.5,	5.22	10.7,	6.18	10.4,	4.44	4.0,	3.5,
D	23	102.7,	8.66	2.4,	1.78	10.8,	4.53	8.4,	4.06	8.5,	3.95	2.6,	2.37
D*	23	111.4,	9.93	4.0,	2.02	18.6,	6.38	15.5,	6.30	14.1,	5.00	3.3,	2.59
E	20	117.9,	9.27	3.9,	3.04	19.7,	5.80	14.5,	6.84	15.4,	3.85	5.2,	2.99
F	28	106.3,	5.40	4.0,	3.29	15.7,	6.44	10.4,	5.51	11.4,	5.11	5.3,	3.98
G*	23	120.9,	8.34	4.4,	2.37	22.8,	4.78	16.7,	6.28	18.4,	4.65	6.2,	4.27
H	19	105.3,	8.74	3.2,	2.30	12.0,	5.51	9.5,	4.98	8.8,	4.52	2.8,	2.02
H*	19	114.2,	9.97	5.5,	1.85	22.0,	3.75	15.8,	3.90	16.5,	3.76	6.2,	3.38
I	23	117.1,	7.35	7.0,	3.48	23.0,	5.83	18.4,	6.47	15.9,	4.03	4.7,	3.00
J	21	104.0,	12.64	4.2,	1.97	15.5,	3.82	11.5,	3.5	11.3,	3.42	4.2,	2.20
J*	16	112.9,	13.87	6.0,	2.42	21.1,	3.75	15.2,	4.05	12.9,	3.69	5.9,	3.79

1. Label Patterns: A=All right side functional; B=Legend; B*=Legend; C=Functional with color; D=Circular; D*=Circular; E=All left side; F=All right side; G*=Half on each side; H=Functional; H*=Functional; I=All on left side, 3 out of line; J=Cross-over; J*=Cross-over.

Table II: Analysis of Variance - Learning Scores
Groups D, F, H, J

Source	Sum of Squares	d.f.	Mean Square	F
Between	169.48	3	56.49	2.85*
Within	1725.42	87	19.83	
Total	1894.90	90		

Table III: Analysis of Variance - Learning Scores
Groups A, B^1, E, D^1, E, H^1, I, J^1

Source	Sum of Squares	d.f.	Mean Square	F
Between	679.34	7	97.05	5.14**
Within	3096.91	164	18.88	
Total	3776.25	171		

Table IV: Analysis of Variance - Learning Scores
Groups A, B, B^1, C, D^1, E, G^1, H^1, I, J^1

Source	Sum of Squares	d.f.	Mean Square	F
Between	1,104.96	9	122.77	5.94**
Within	4,302.38	208	20.68	
Total	5,407.34	217		

* - Significant at the .05 level of confidence
** - Significant at the .01 level of confidence

Delayed retention scores).

Examination of Table I suggests heterogeneity of intelligence scores amongst class groups exposed to different label patterns. As indicated in an earlier footnote, circumstances did not permit the complete replication of high and low IQ groups with each label pattern. Further inspection of this table suggests variation amongst treatment groups in terms of preknowledge of the labels as well as differences in acquisition and retention.

In light of the variation in measured intelligence of the various treatment groups, it was decided to assess the significance of treatment effects by: (1) performing an analysis of variance of learning scores on the four treatment groups having the lowest relatively homogeneous level of intelligence (groups D, F, H, J), (2) on the treatment groups (A, B^1, C, D^1, E, H^1, I, J^1) having mean IQ's of from 110-117, and (3) on all treatment groups with the exception of D, F, H, J. (A, B, B^1, C, D^1, E, G^1, H^1, I, J^1). The results of these analyses are reported in Tables II, III, and IV.

Table II reveals an F ratio significant at the .05 per cent level of confidence. T-test analysis of these four treatment groups revealed significant differences (.05 level) between groups D and F, and D and J with all other comparisons failing to reflect significant differences at the .05% level of confidence. These findings suggest that with relatively low IQ, pupils circular (D) patterns of labels are disadvantageous in contrast to other patterns (F, H, J).

Table III reveals an F ratio significant at the .01 per cent level of confidence. T-test analysis of these eight treatment groups revealed significant differences at the .01 and .05 levels of confidence as follows: A x B,

A x C, B^1 x H, B^1 x I, B^1 x J^1, C x D^1, C x E, C x H^1, C x I, and C x J^1. All other comparisons fail to reflect differences significant at the .05 per cent level of confidence. The essential meaning of these analyses seems to be the legend (B^1) and the functional grouping of colored labels (C) are associated with fewer gains in learning than other patterns (A, D^1, E, H^1, I, J^1).

Table IV reveals an F ratio significant at the .01 per cent level of confidence. T-test analysis of these ten treatment groups is the same as that associated with Table III, with the exception that additional significant differences at the .01 and .05 per cent levels of confidence between groups B x B^1, B x C, B^1 x G^1, C x G^1, D x G^1, G^1 x J^1, and E x G^1. The essential implication of these additional significant T-tests is that with "bright" students the legend pattern is not disadvantageous and further that pattern G^1 (half the labels on each side) is extremely well learned by "bright" students.

Analyses of variance paralleling those of Tables II, III, and IV were done using the forgetting scores described in Table I. The only significant F was found among the poor "low" ability groups D, F, H, and J which was significant at the .01 per cent level of confidence. Subsequent T-tests revealed significant differences in forgetting between D x F and F x H at between the .01 and .05 per cent levels of confidence. The essential implications of these findings appear to be that patterns D (circular) and H (functional) in "low" IQ groups are associated with lowest amounts of forgetting.

Discussion of Results

Obviously the inability to replicate all label patterns with comparable ability groups (IQ) of subjects makes the task of evaluating the experimental treatments difficult. Likewise, the considerable variances associated with the

various performance measures contribute to equivocal interpretation. Nonetheless, a number of inferences seem worthy of being drawn if only to serve as hypotheses for future research.

First it would appear that within substantial ranges of alternative design, variations in the spatial arrangement of labels are not associated with different degrees of learning or retention on the part of normal to bright high school students, e.g. A, D^1, E, I.

Secondly, even when apriori reasons would suggest that selected patterns (e.g. Legend, Circular, X-over) would hinder learning by requiring "excessive" visual fixations, extra "decoding" and confusing referents, normal to high ability subjects seem to compensate adequately and are not susceptible to disruptions in acquisition.

Thirdly, with "low" ability groups (D, H, F, J), patterns which deviate from the "conventional" listing of labels to one side of the pictorial material seems to cause difficulty in acquisition.

Fourthly, it appears that though we may tentatively assign to label patterns a determining role in acquisition, such differential influences seem to vanish in retention; at least when one uses absolute measures of forgetting (i.e. number of labels given on retention subtracted from number given immediately after learning). Inspection of the data does suggest that the greater the amount learned, the greater the amount forgotten (Spearman Rho + 0.82 using group means for learning and forgetting).

The above inferences have implications primarily at the level of design recommendations. However, the data do provide at least one relatively clear test of theory. Groups E and I differ in treatment in that three of the labels

in I are unaligned (uneven) with the remaining twenty-seven labels whereas all thirty labels in E were aligned with each other. The unaligned condition (I) should lead to heterogeneity of the task elements and according to Gestalt theory lead to better mastery of the total task. Such a difference was not found in either learning or forgetting even though the pre-learning score for the I group was somewhat higher than for Group E.

Summary and Abstract

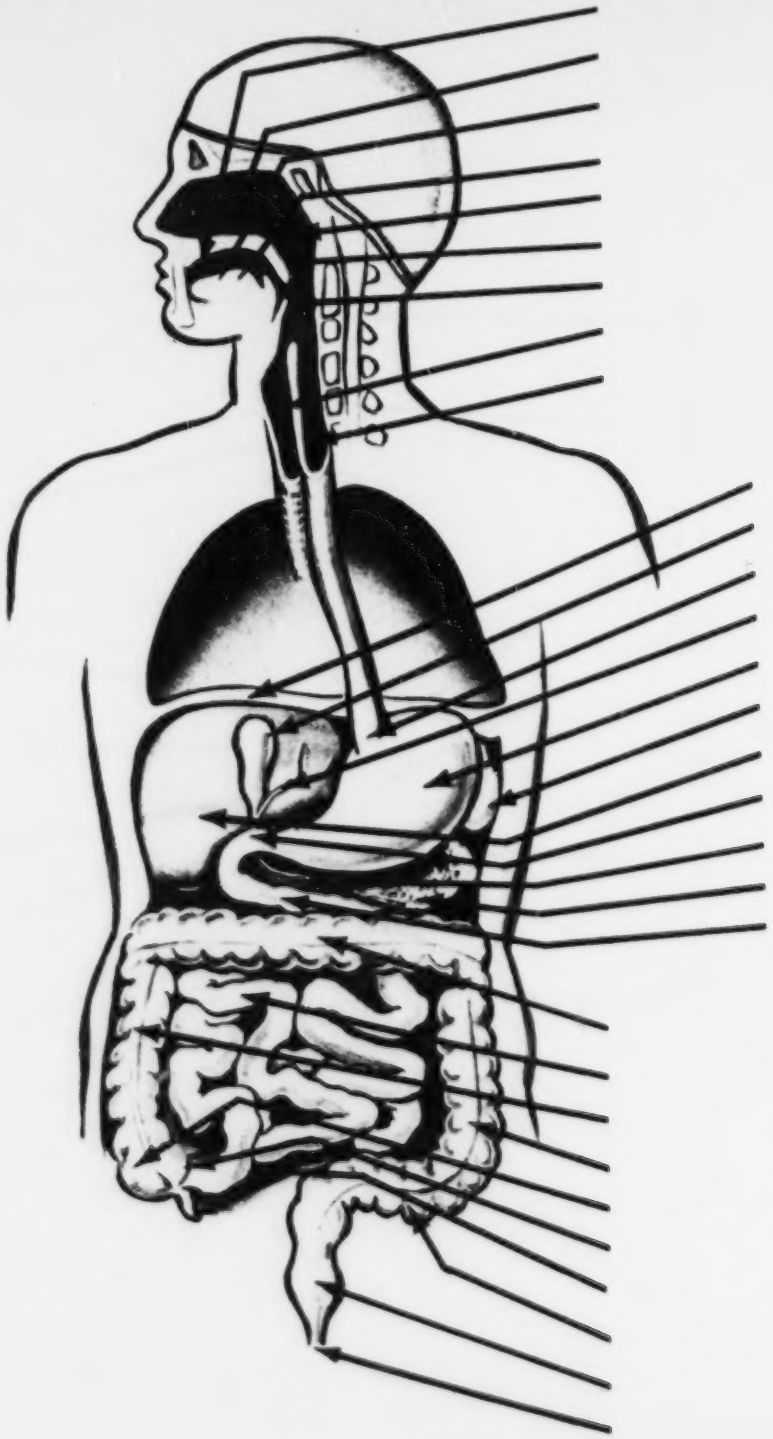
Class groupings of high school students (14 groups; total N = 309) learned labels from a visually projected chart containing biological information (i.e. diagram of human digestive system with verbal labels). Different class groups learned from displays varying in the spatial arrangement and characteristics of the label patterns. Though the influence of simultaneously varying ability levels (IQ) tended to confound the findings, the following conclusions and hypotheses were suggested:

A. Several variations of label patterns appear to have equivalent influence on acquisition and retention thereby providing an emperical basis for alternative layouts by designers of such educational displays.

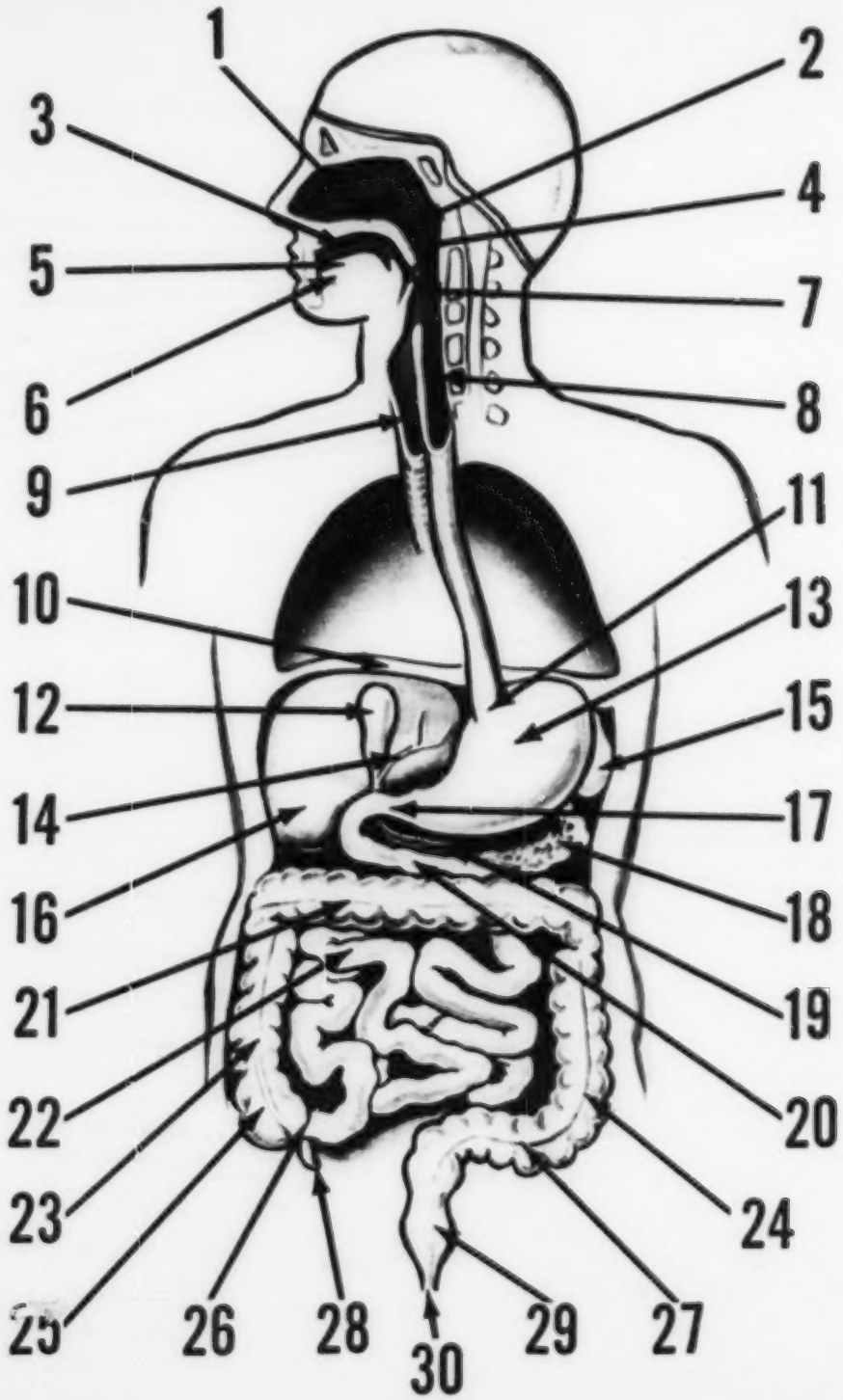
B. Though a variety of a priori hypotheses suggested that certain label patterns and characteristics might be associated with differential advantage and retention, the circumstances of the current research fail to demonstrate or corroborate them, e.g. heterogeneity of label alignment better than homogeneity of label alignment, implied functional versus non-functional grouping of labels, the presence or absence of color to enhance groupings of labels, etc.

APPENDIX

THE HUMAN DIGESTIVE SYSTEM



THE HUMAN DIGESTIVE SYSTEM



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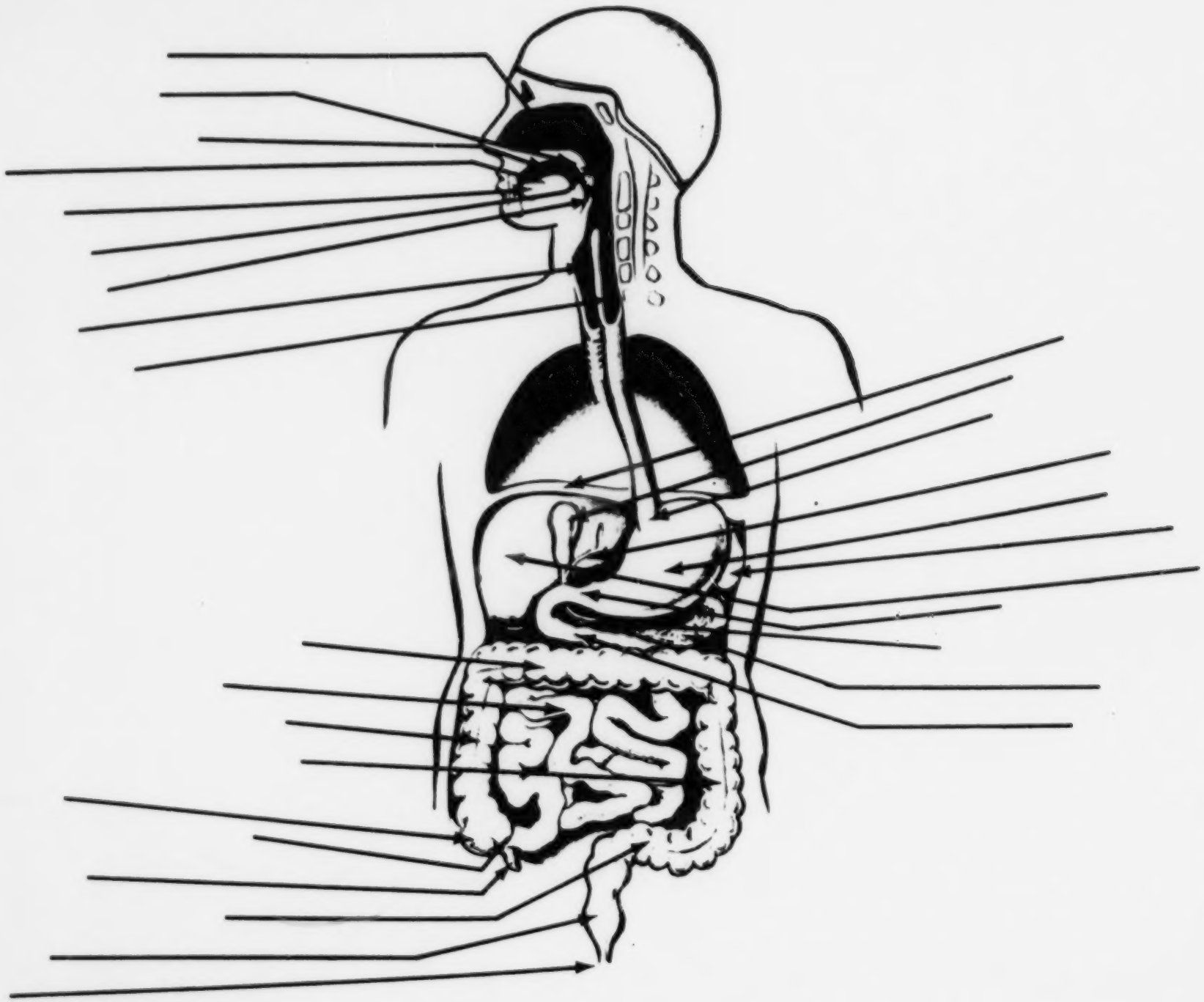
THE HUMAN DIGESTIVE SYSTEM



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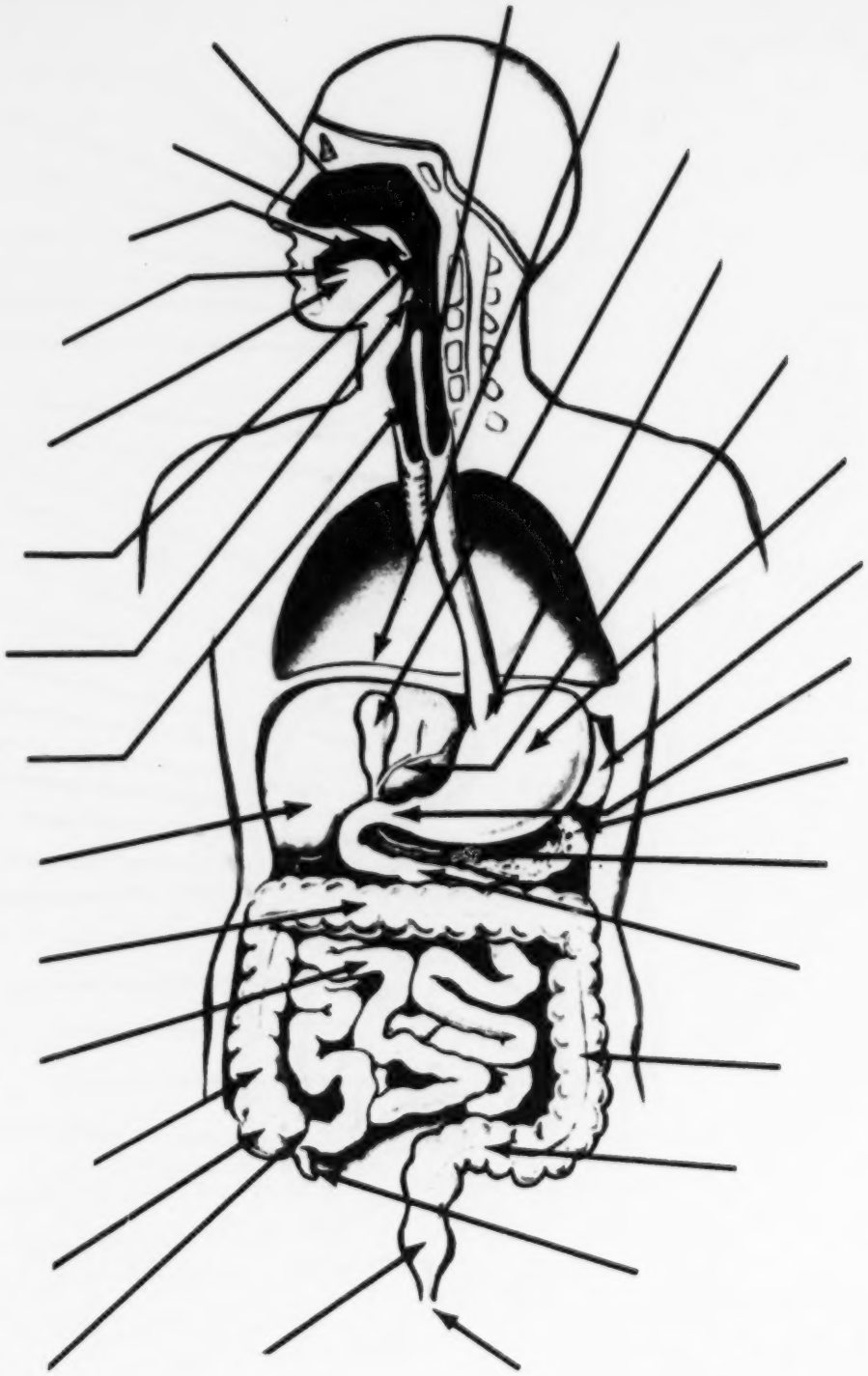

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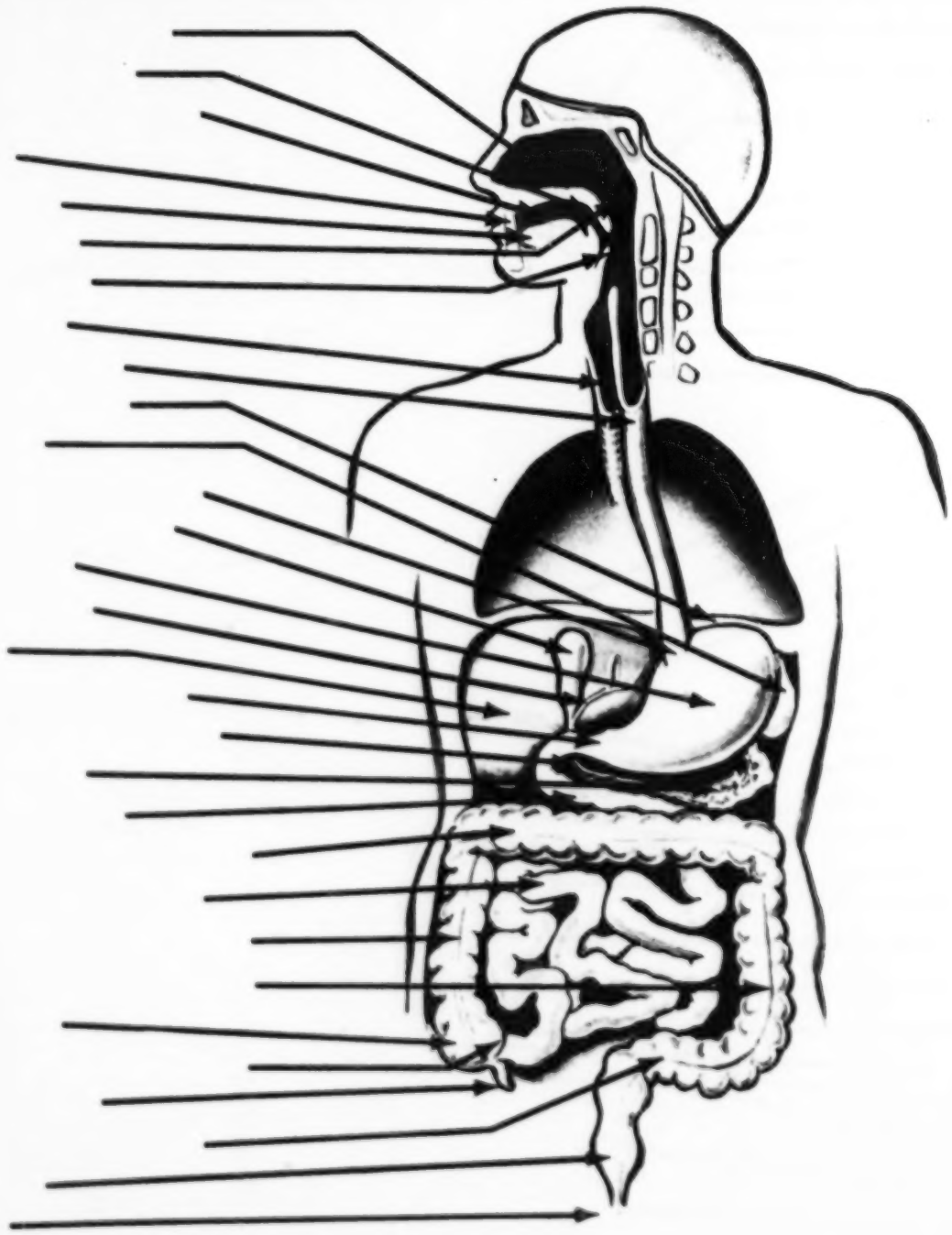
THE HUMAN DIGESTIVE SYSTEM



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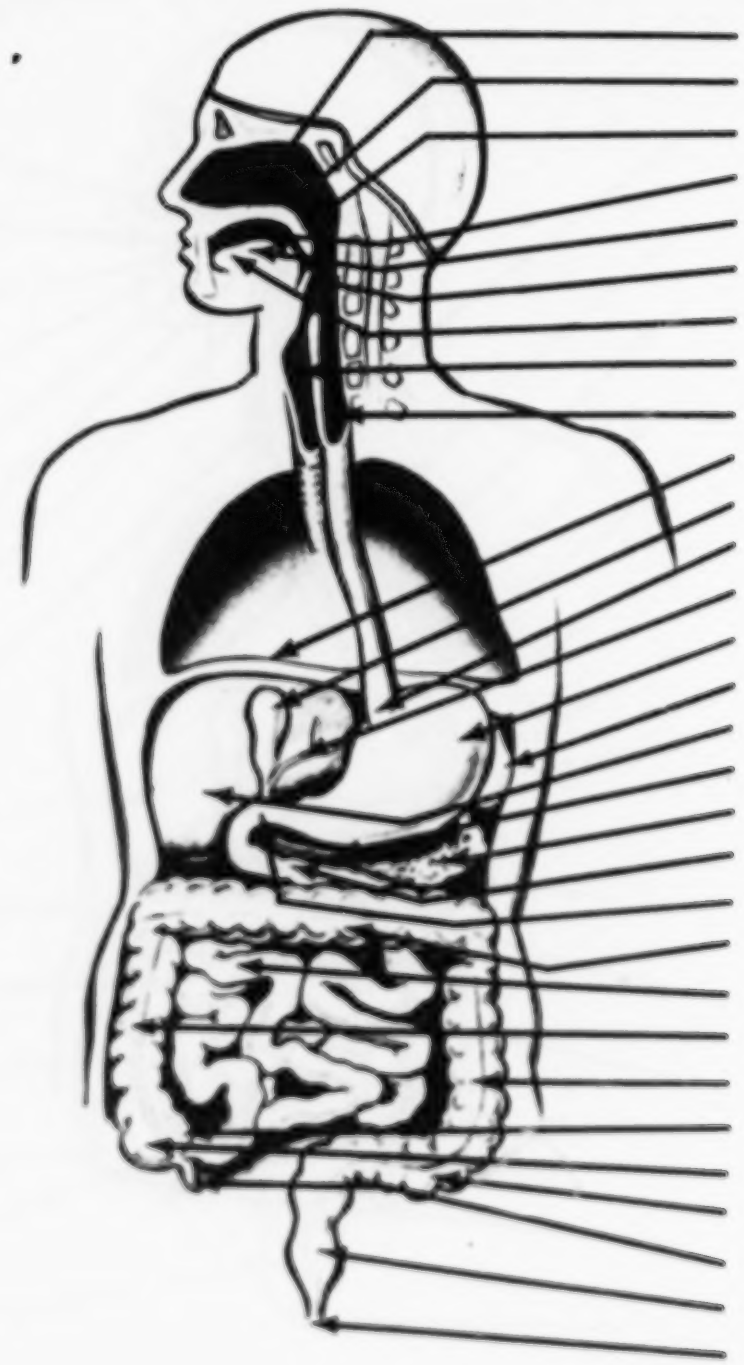

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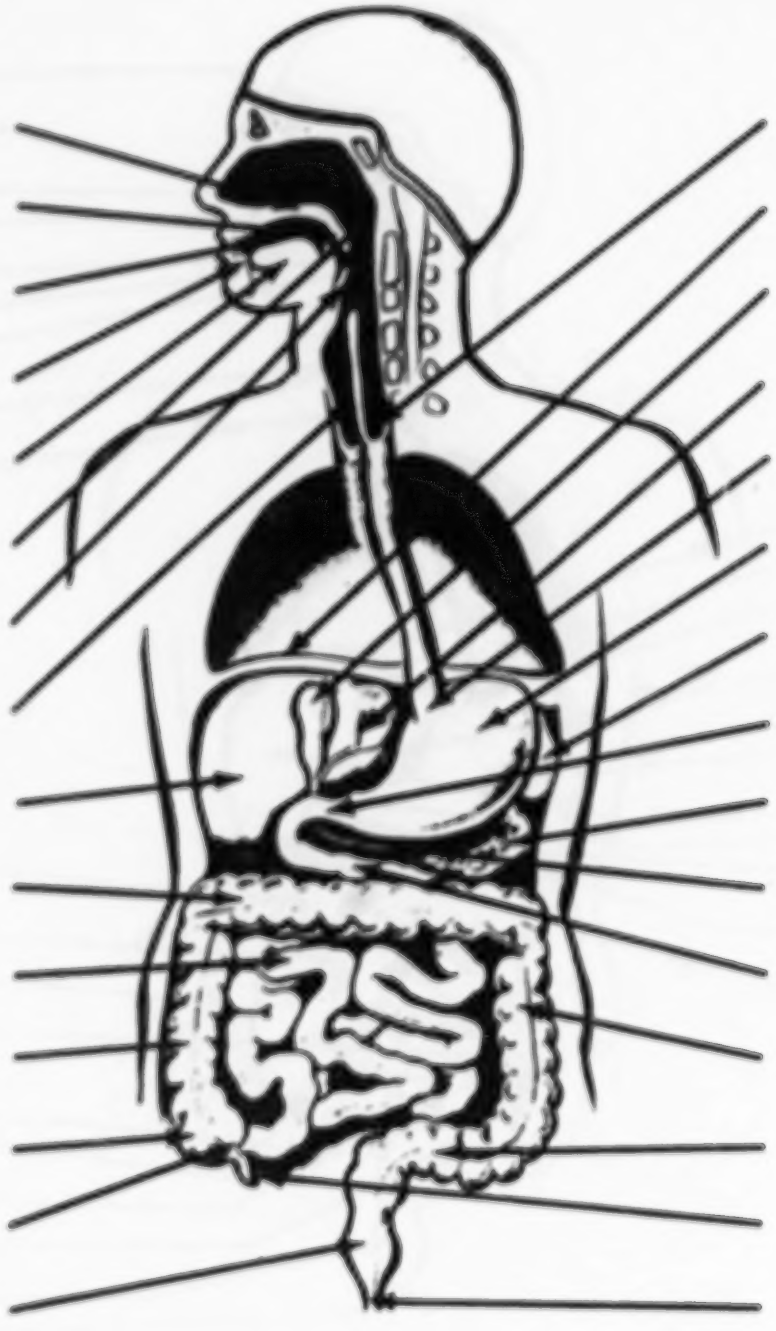

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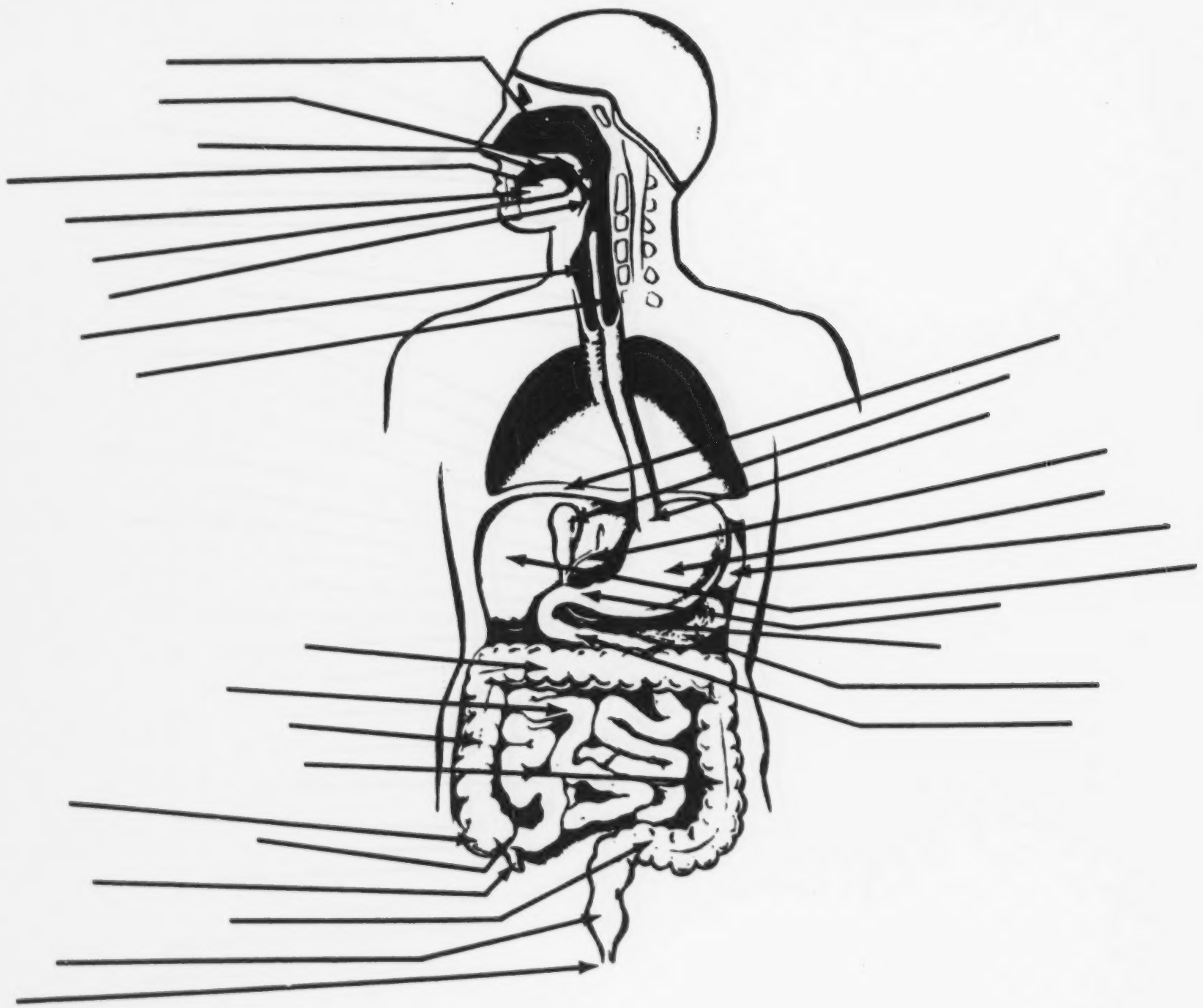

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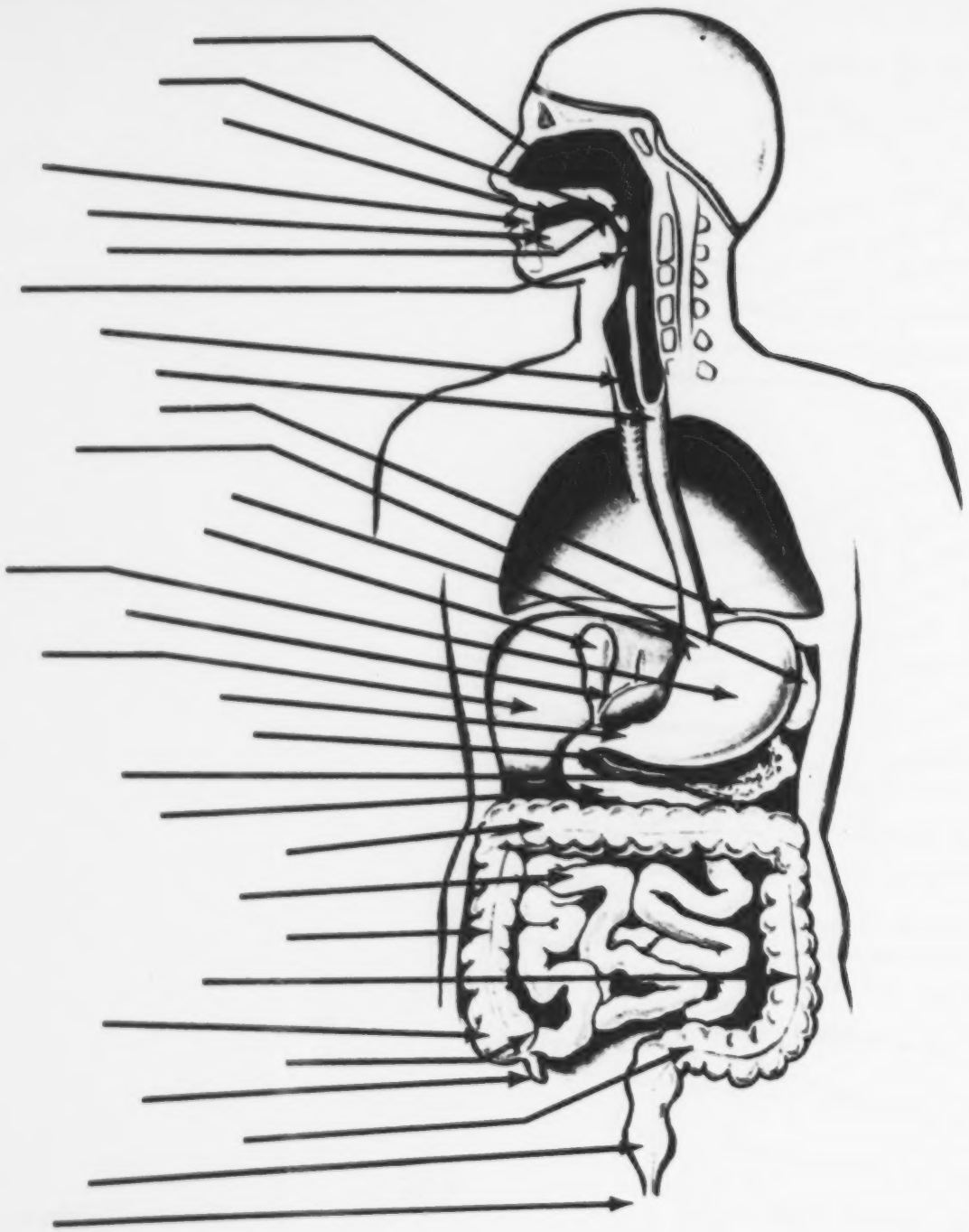

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